Influence of Electrode Force Affecting the Complete of the Resistance Spot Welding

Prachya Pearsura*
Department of Production Technology Education, Faculty of Industrial Education and Technology, King Mongkut's University of Technology Thonburi, Thongkru, Bangkok 10140
**Corresponding Author* : prachya.pea@kmutt.ac.th

Abstract

This research was to influence of electrode force affecting the complete of the resistance spot welding. The specimen was mild steel sheet metal has 1 mm. thickness. Then applied the force to the specimen are 1.0, 2.0, 3.0, 4.0 and 5.0 kN. The welded specimens were tested by tensile shear testing according to JIS Z 3136: 1999 and Macro structure testing according to JIS Z 3139: 1978.The results showed that electrode force had affected on tensile shear and nugget size at 95% confidential (P value > 0.05). The low electrode force had increase the nugget heating because it had a high resistance ($Q=I^2Rt$) and increase the gab between specimen. When the resistance increasing so the current flow will difficult to passed that fusion zone will had a high heating. It will affected to nugget seize, heat affected zone and mechanical properties decreasing. The electrode forces are complete 2.0 kN. Tensile shear 6.39 kN and Nugget Size 5.83 mm. This data can be applied to be used as process monitoring of resistance spot weld quality

Keywords: Resistance Spot Welding, Electrode Force, Tensile Shear, Nugget Size

1. Introduction

Resistance spot welding is a type of welding process in use by automotive, furniture, building construction and electrical-electronics industry. There is the most common application because it can weld the work pieces speedily with high quality and less thermal effect, strong enough to use and easy method for operating. The operating systems of resistance spot welding were: 1) Electrode set-down 2) Squeeze 3) Current Flow 4) Forging 5) Hold Time and 6) Lift-off). Resistance spot welding has three mainly components: 1) Heat 2) Pressure and 3) Time. The quality problems which occur after welding are the indicators that being the complete welds or not. Due to the present checking process via the nondestructive can not respond to the requirements for checking but using checking process via the destructive. From these reason, it may occur troubles on the cost of production, lose checking time and lose time in producing new work pieces according to incomplete welds.

The complete work pieces by resistance spot welding consist of various components such as the electrical current, pressure and current flow. Therefore, the study of optimal of electrode force to resistance spot welding was the important factor. If using much or less electrode force, it would have affected the mechanical property which reduced the strength of work pieces. Quality requirements used in this research were mechanical property test and macro test being the criteria for considering the quality of specimens. The results of this research could be the basic data in making research or being the information for quality control resistance spot welding.

2 Equipments and Experiment Method

The specimen tested was mild steel which passed cold polling process with a thickness of 1mm. Specimen preparation following JIS Z 3136: 1999 by cutting specimen 30 mm in wideness and 100 mm in length. The electrode was used truncated radius electrodes (TR) following JIS C 9304:1999 with electrode 6 mm in diameter. Electrode force was consisting of 4 levels as 1, 2, 3, 4 and 5 kN. Time current flow was 8 cycle at current flow 8 kA and testing on each about 20 sample following JIS Z 3136:1999, JIS Z 3139:1978, and JIS Z3140. After process of experiment , specimen were tested the strength of a weld by Tensile Shear testing following JIS Z 3136:1999 using 10 specimens on each test. In addition specimen was measured on Macro Structure for the weld nugget size following JIS Z 3139:1978 with 10 specimens by Image Measurement Machine (Fig. 1). Then, an analysis of data gathered to find for the complete welding following JIS Z 3140 and one way ANOVA analyses.

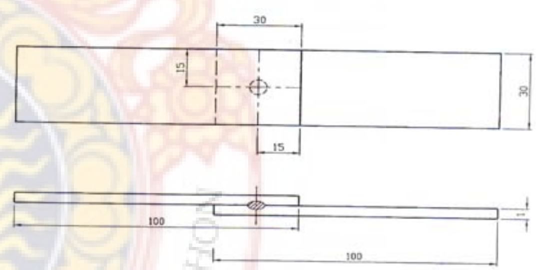

Fig 1 Specimens follow by JIS Z 3136:1999, JIS Z 3139:1978, and JIS Z3140

3 Results

3.1 Results of Tensile Shear testing

Tensile Shear testing was the test on mechanical property of weld for measuring Tensile Shear which using 10 specimens for each testing according to JIS Z 3136:1999.

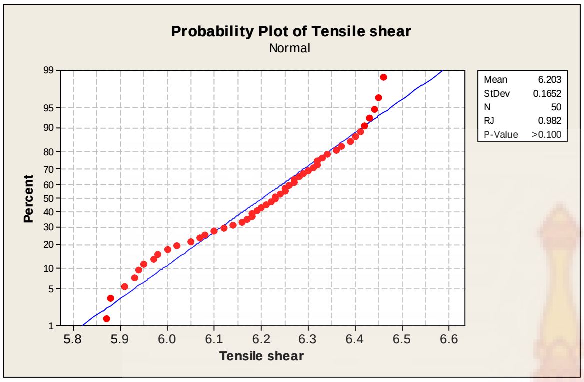

Fig.2 Probability plot of tensile shear

As shown Fig.2, Probability plot of tensile shear the data has normal distribution P value > 0.05

Table 1 One-way ANOVA: Tensile shear versus Electrode force

Source	DF	SS	MS	F	P
Electrode force	4	1.0898	0.2724	49.66	0.00
Error	45	0.2469	0.0054		
Total	49	1.3368			

S = 0.07408 R-Sq = 81.53% R-Sq(adj) = 79.89%

As shown Table 1, One-way ANOVA: Tensile shear versus Electrode force. The results showed that of electrode force had affected on tensile shear at 95% confidential (P value < 0.05)

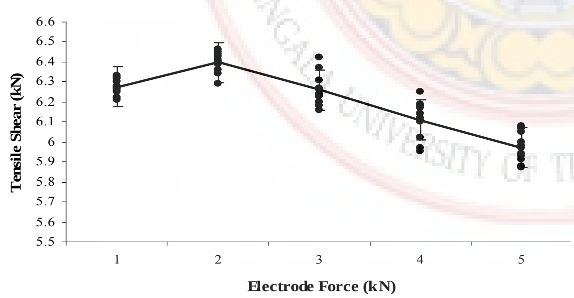

Fig. 3 Results of Tensile Shear testing compared with Electrode Force

As shown in Fig.3, Tensile Shear of weld had high value until to the pressure at 1 kN with the highest value of Tensile Shear. Because increases the gab between 2 specimens so pressure had affected to weld specimens' quality. Affect of this result made current flow decreasing so the resistance and heat increasing follow by equation (1)

$$Q = I^2 Rt \quad (1)$$

Where
Q = Heat (Jool)
I = Current (Ampere)
R = Resistance of Base Metal (Ohm)
t = Time Current Flow (Second)
Temperature (ΔT) Calculate for Q follows equation

$$\Delta T = Q = I^2 Rt / mCp \quad (2)$$

Where
m = mass of material
Cp = Heat capacity

Fig. 4 Tensile Shear specimens at electrode force 1 kN

Fig.4, the specimen at electrode force of 1 kN, it was found that it was torn apart through Heat Affected Zone due to the time of current flow was too much, so it occurred more quantity of heat which affected the Heat Affected Zone having a width greater with least strength and having a torn apart including reducing the strength. The specimen at electrode force of 2 kN was found that it was torn apart through the nugget due to the nugget size had equal strength as the weld. Normally, the complete welds need least strength equal to the specimen.

3.2 Results of Macrostructure

Macrostructure test, Diameter Nugget Size and a percent of penetration were measured by Image Measurement Machine. The measuring regarded to the nugget size and a percent of penetration with 7x magnification in millimeter unit.

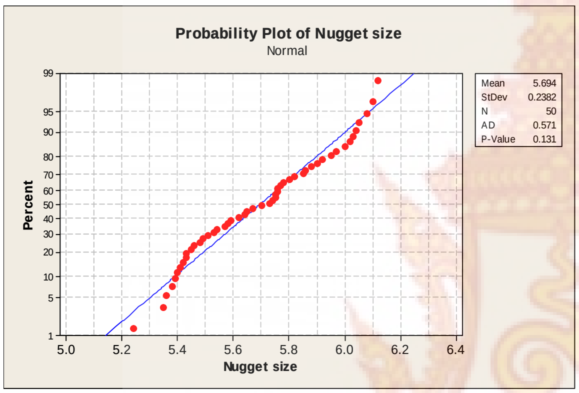

Fig. 5 Probability plot of nugget size

As shown Fig.5, Probability plot of nugget size the data has normal distribution P value > 0.05

Table 2 One-way ANOVA: Nugget size versus Electrode force

Source	DF	SS	MS	F	P
Electrode force	4	2.6433	0.6608	217.86	0.00
Error	45	0.1365	0.0030		
Total	49	2.7798			

S = 0.055 R-Sq = 95.09% R-Sq(adj) = 94.65%

As shown Table 2 One-way ANOVA: Tensile shear versus Electrode force. The results showed that of electrode force had affected on nugget size at 95% confidential (P value > 0.05)

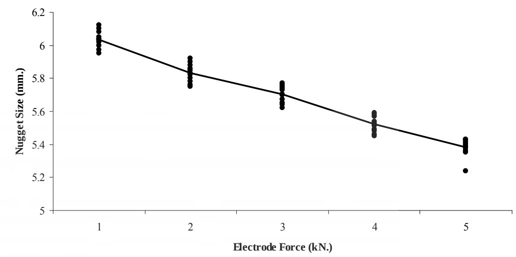

Fig. 6 Nugget Size compared with Electrode force

As Fig.6, it low electrode force had increase the nugget heating because it had a high resistance (1) and increase the gab between specimen. When the resistance increasing so the current flow will difficult to passed that fusion zone will had a high heating. It will affected to nugget in acceptance criteria depending on suitable rate at 20-80 %[5], so that could be acceptance.

3.3 Results of complete welding analysis

The comparison analysis of electrode force on specimens with results analysis between Tensile Shear and nugget size for determining the level of pressure using in complete welding as shown in the following in fig 7

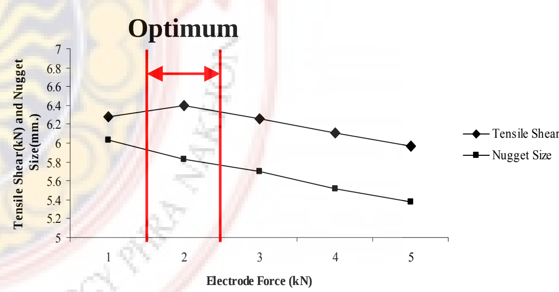

Fig. 7 Testing Results of Nugget Size and Tensile Shear compared with Electrode force

Consequently, considering of electrode force on specimens comparing with Tensile Shear the acceptance criteria of Tensile Shear for steel had 4.9 kN [1] electrode force was in acceptance criteria [4] since pressure of 1 kN Tensile Shear and pull-outlet fracture [3] due to the nugget size had more strength than specimens. The results were showed that the optimal of was electrode force 2 kN-5 kN

Furthermore, the considering of nugget size according to standard [2] in considering the suitable melting rate at 20 -80% [5]. The results were showed that the optimal size of nugget was electrode force 2 kN-5 kN. However, in the electrode force 1 kN., the melting rate had more than 80% so that could be acceptance.

4. Conclusions

The results showed that of electrode force had affected on tensile shear and nugget size at 95% confidential (P value > 0.05). The low force had increase the nugget heating because it had a high resistance ($Q=I^2Rt$) and increase the gab between specimen. When the resistance increasing so the current flow will difficult to passed that fusion zone will had a high heating. It was affected to nugget seize, heat affected zone and mechanical properties decreasing. The electrode forces are complete 2.0 kN. Tensile shear 6.39 kN and Nugget Size 5.83 mm.

According to the results, it could be used in resistance spot welding on alternating-current welding or being the decision making basic in selecting suitable variables for the strength, nugget size and suitable melting rate with the next resistance spot welding. This research can be implemented to quality control process and database for resistance spot welding.

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